Development of Conformal Ablative Thermal Protection Material and Fabrication Process

Completed Technology Project (2014 - 2018)

Project Introduction

An entering spacecraft must decelerate from speeds of kilometers per second to zero in the span of only minutes ☐ a sequence aptly dubbed ☐Seven Minutes of Terror☐ on Mars Science Laboratory. Most of this kinetic energy is converted to thermal energy as the vehicle decelerates in the atmosphere. A thermal protection system (TPS), or heatshield, forms the outer surface of the spacecraft and provides critical protection from this intense heating. Whether returning from Earth orbit or entering other planetary atmospheres, a TPS is crucial for mission success. The proposed research seeks to advance the readiness of new conformal ablative TPS materials and their corresponding fabrication process to (1) address NASA goals for lower cost, lower mass, more sustainable TPS systems and (2) make TPS accessible to small companies, universities and research labs, which historically have not possessed the resources for such technology. Ablative TPS, a particular class of TPS material, have been used almost exclusively for planetary probes to date. However, these materials require often complex, labor-intensive fabrication processes. Conformal ablators have the potential to simplify manufacturing and assembly by utilizing flexible, high strain-to-failure component materials. Therefore, it can be formed in large segments and directly bonded to an aeroshell without gap fillers. As a result, reliability is increased and cost and complexity decreased compared to traditional materials. In turn, these improvements can drive TPS cost and mass fraction down. Conformal TPS is a composite material consisting of a carbonized rayon felt substrate infiltrated with an organic resin. By leveraging related techniques in composites fabrication, this research will streamline the manufacturing process, ultimately, leading to improved material consistency, process standardization and the production of a complete small-probe aeroshell. Investigations will include vacuum bagging (to improve resin infiltration), automation (to limit manual labor) and novel folding methods (to form larger, curved segments). Alternative, more environmentally-friendly resin materials will also be evaluated. These improvements can advance conformal ablators from the current state-of-the-art to a high technology readiness level. The proposed work addresses future mission needs for Earth, Mars and other planetary entries while realizing significant system-level benefits such as increased production speed, increased material consistency, reduced cost and reduced environmental impact in TPS manufacturing. Such a low-cost, easily manufactured and reliable TPS can benefit both small- and large-scale NASA missions and expand access to recoverable missions to the broader space community.

Anticipated Benefits

These improvements can advance conformal ablators from the current state-of-the-art to a high technology readiness level. The proposed work addresses future mission needs for Earth, Mars and other planetary entries while realizing significant system-level benefits such as increased production speed,

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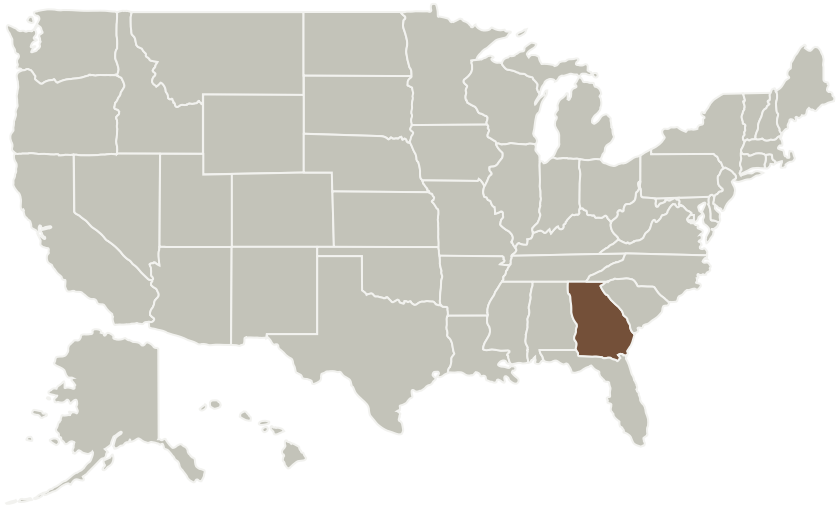
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Georgia Institute of Technology-Main Campus(GA Tech)	Lead Organization	Academia	Atlanta, Georgia

Primary U.S. Work Locations
Georgia

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Georgia Institute of Technology-Main Campus (GA Tech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Robert D Braun

Co-Investigator:

Adam T Sidor

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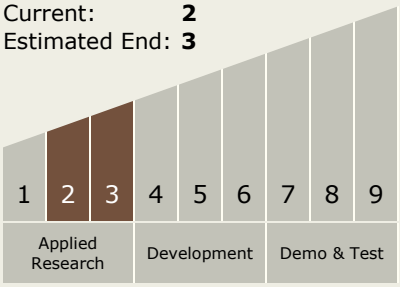
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - TX09.1 Aeroassist and Atmospheric Entry
    - TX09.1.1 Thermal Protection Systems

Target Destinations

Mars, Earth, Others Inside the Solar System